



WATER RESOURCES RESEARCH GRANT PROPOSAL

TITLE: Development of an Innovative Kenaf-Based Biosorptive Water Treatment Process

FOCUS CATEGORIES: GW, TRT, TS

KEYWORDS: Hazardous wastes, groundwater quality, pollution control

TIMELINE: March 1999 - February 2001 (Two Year Duration)

FEDERAL FUNDS REQUESTED: \$5,090 (YR1) and \$5,097 (YR2)

NONFEDERAL FUNDS COMMITTED: \$ \$15,910 (YR1) and \$15,903 (YR2)

CONGRESSIONAL DISTRICT: No. 3 - Mississippi

PRINCIPAL INVESTIGATOR: Dr. Mark E. Zappi, P.E., Director of the Environmental Technology Research and Applications (E-TECH) Laboratory, Dave C. Swalm School of Chemical Engineering, Mississippi State University (MSU)

RESEARCH NEED

Many of the contaminated surface waters and groundwaters currently undergoing treatment or scheduled for treatment contain organic contaminants at relatively low levels (sub-100 ppm levels); yet, these levels are still well above regulatory requirements requiring treatment prior to discharge. Recent pollution prevention initiatives within industry have resulted in wastewaters that do contain lower levels of contamination; however, these waters still contain contamination levels requiring treatment. The treatment of these waters pose both technical and economic challenges to industry and site owners (Acar and Zappi 1995). With regard to Mississippi, many industries are small businesses that are already stressed by the challenges of today's market conditions. Having to face complex environmental compliance issues, such as water treatment, only further exasperates their situation. However, these water sources do require treatment to preserve/restore the resource quality (and keep the company in compliance).

Currently available treatment technologies usually have problems treating these waters. Typically, these influents do not contain sufficient organic substrates to adequately support biotreatment units (Zappi et al. 1993). Many of these chemicals cannot be air stripped because of low volatility (Haas and Vamos 1995). Plus, current regulatory guidance requires treatment of air exiting air stripper units due to concerns over air pollution. Chemical oxidation offers an alternative; however, these techniques are developing, somewhat costly, and often require highly trained operators due to system complexity (Langlais et al. 1991). Also, the presence of hydroxyl radical scavengers within the influents and poor influent UV transmissivity adversely impacts oxidation

process performance (Zappi 1995). Activated carbon adsorption offers a viable option. However, activated carbon has limitations in that spent carbon must be transported off-site for disposal or regeneration. Therefore, the state of affairs facing engineers and scientists attempting to treat low level contaminated waters using the above discussed technologies results in the selection of a process that has significant short-comings. A technically superior, yet operationally simpler treatment process within a reduced cost bracket is needed to assist industries in meeting environmental regulations. An operationally-simple system would improve the quality of endangered water sources because of increased usage by industry resulting in cleaner discharges.

PROPOSED PROCESS

A novel process is proposed that will address the shortcomings of the technologies discussed above, while meeting the needs of industry. The envisioned process involves adsorption of organic contaminants onto crushed kenaf fibers. Kenaf is a plant that is in the same plant family as okra. Kenaf is an agricultural crop that has recently been found to have many uses including animal litter, paper manufacturing, and composite material construction. Recent unfunded research at MSU indicates that kenaf has a high sorption capacity for organic contaminants (discussed later). The fibers of the kenaf plant are resistant to water logging and are structurally stable when exposed to overburden loads allowing tight, yet sturdy packing. Kenaf fibers will be packed into a column where contaminated water will be passed through the column using up-flow hydraulics to provide intimate contact between contaminated water and the kenaf fibers. The contaminants will adsorb onto the sorptive sites on the kenaf and the column operated until all of the kenaf fibers within the column are completely spent (i.e. all sorption sites filled). This approach is very similar to that used with activated carbon adsorbers; however, once the kenaf becomes spent, then the fibers will be removed and placed into a compost bed (see attached drawing). The compost bed will be used to reduce waste kenaf volume and degrade the adsorbed chemicals via biotreatment.

RESEARCH BENEFIT

Benefits expected with the development of the proposed process are: a. The kenaf-based biosorptive process is expected to be much cheaper than activated carbon in that kenaf is a renewable resource that is easily cultured within the Southeastern United States. MSU is actively involved in the discovery of innovative uses of kenaf. This effort is managed under the MSU Kenaf Research Program housed within the Department of Agriculture and Biological Engineering. Past research efforts by the MSU Kenaf Research Team have refined growing protocols and plant material processing techniques to economically grow and process kenaf. The plant fibers are easily prepared using processing techniques that economically wash, crush, and segregate the various fractions. Alternatively, activated carbon requires aggressive processing of carbaceous materials (nutshells, bone, or coal) that involves high temperatures and pressures; both of which are very costly. Cost estimates place carbon at \$1.50 versus less than \$0.10 per lb. kenaf.

b. Kenaf fibers are easily stored and extremely stable under high impact and overburden stresses. Activated carbon is easily crushed to useless fines under similar handling conditions. In fact, to retain structural stability, activated carbon is usually loaded into and out of adsorber vessels using water-carbon slurries which increases system complexity and cost.

c. Composting is a well developed process that has been widely used for disposal of plant debris and stabilization of municipal biosolids. The final product from compost systems, including the type proposed within this process, is a humus-based material that has a marketable value as a agricultural amendment (Maynard 1995). Using composting to dispose of the spent kenaf fibers will also result in the on-site degradation of the adsorbed contaminants meaning that the proposed process is a destruction treatment process that will eliminate the pollutants as an environmental and regulatory problem. Carbon must be transported off-site and regenerated using special equipment that utilizes high temperature and pressures to destroy the contaminants.

PROJECT OBJECTIVES

The overall objectives of this project will be to develop and prove the utility of the kenaf biosorption process for treating contaminated waters. Secondary objectives to be addressed include:

a. Evaluation of the adsorptive capacity of candidate kenaf fibers composed of various plant fractions and/or fibers made from differing processing techniques for three phenolic compounds (phenol, dichlorophenol [DCP], and pentachlorophenol [PCP]). The rationale for selecting phenols will be discussed in the next section.

b. Evaluation of the stability of the various fibers within saturated column reactors under long-term, dynamic operational flows.

c. Evaluation of various composting approaches for both reduction of plant mass and degradation of phenolic compounds.

d. Determination of the extent of mineralization achieved for the phenolic compounds within the compost reactors.

e. Evaluate the impact of chlorination level on the rate of adsorbed phenolic compound degradation within the compost reactors.